THE PATH OF THE VASO-MOTOR, SUDORIFIC, AND SENSORY NERVES IN THE SPINAL CORD.

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AFTER a hemisection of the spinal cord the previously narrow capillaries dilate, which proves that vaso-motor nerves exist in that side of the cord. Heretofore dilatation of the capillaries and increase of temperature were the main proofs in regard to the path of the vaso-motor nerves. Ludwig and Nicolaides have tried a somewhat new procedure, by stimulating with induction currents the nerves going to the place of partial paralysis of the vaso-motor nerves, which had been produced by a hemisection of the spinal cord. On rabbits under curare, with artificial respiration kept up, they cut the cervical cord at the second cervical vertebra and placed platinum electrodes on the transverse section of the cord and closed the wound. Then in the lower part of the dorsal region, by means of a protecting knife, a hemisection was made of the spinal cord. To observe the capillaries they chose a place where the vaso-motor nerves exclusively arise below the second section, that is, the kidneys. They can be easily bared on both sides without disturbance of the circulation, and can be brought into view by a section through the skin and fascia of the back. Their carmine color shines so long as the blood runs into them, and they become of a gray-red color when the supply is cut off. Their nerves emerge from the spinal cord on a line between the dorsal and lumbar region. If the spinal cord is divided completely between the 11th and 12th dorsal vertebræ, irritation of the cervical section of the spinal cord will not change the color of the kidneys in the least degree. However, they pale in color when the section is between the 1st and 2nd lumbar vertebræ, and the cervical cord is irritated. During the irritation the kidney of the sound side lost its redness first and simultaneously over its whole surface, whilst the other kidney on the side of section began to pale later, here and there, in spots. Whilst they proved this to be true of the blood-vessels of the kidney they did not succeed in proving it in regard to other bilateral vaso-motor innervation. They tried hemisection of the spinal cord, and irritated a sensory nerve, and noted the rise of blood pressure. They found that the same nerve after the hemisection became more irritable than it was before the section; the nerve on the side of section is meant. They found that after hemisection the arterial tension was depressed not at all, or very little. Their results were not sufficiently (as they state) marked to prove the bilateral vaso-motor innervation for one half of the cord in regard to other districts. In another place I have studied the location of the centres of the vaso-dilator nerves for other organs, the posterior pulps of the cat by the heat-test, and found that they are located between the 10th dorsal and the 1st lumbar vertebræ. The pulps were also noted to have rhythmical changes in their color every thirty seconds, especially during the heat-test. These experiments reminded me that the unpigmented soles of the cat's feet would be a valuable point from which to determine if the law about the vaso-motor innervation of the kidney would hold good in regard to the skin of the pulps.

Method.—My experiments were made on cats with unpigmented pulps of the posterior extremities. They were chloroformed, bound down, curarized, artificial respiration kept up by a water motor, the cord bared in the dorsal region, nearly on a line with the posterior edges of the scapulæ, and a hemisection made with the protecting knife of Woroschiloff. It was then bared in the cervical region, under the second cervical vertebra, and a complete section was made. After curarization the posterior extremities were loosened that the circulation in them would not be disturbed by the ligatures. Then, when the feet were quite vascular, the cord was irritated by means of electrodes in the cervical region, and the paleness of both feet noted. It soon came on after the irritation. It must be remembered that the pulps of the cat normally have a rhythmic movement of the walls of the blood-vessels, which must not be confounded with that taking place through the irritation, which causes much greater paleness. In some cases, after frequent irritation, the vaso-dilator nerves come into play, the feet becoming more vascular than normal. In several cases, after the test, the cord was completely divided three millimetres below the hemisection, and the cervical cord irritated to see if there was any spreading of the current. In these experiments the sweat secretion was noted to take place on both sides after the hemisection. Hence the conclusion was reached, that after a hemisection of the spinal cord the vaso-motor changes and the sudorific functions of the posterior extremities can be called into activity through the opposite half of the cord. That these changes could not have taken place through the abdominal sympathetics having vaso-motor and sudorific fibres, is proven by the fact that section just below the hemisection completely arrested these changes which previously took place. Also, the fibres in the abdominal sympathetics leave the cord lower down than the hemisection, which was usually about the seventh dorsal vertebra, or higher up. To decide the path of the sensory nerves, I employed the test of blood pressure, which, so far, has only been used to determine the path of the sensory nerves in rabbits. It is highly important that all these tests should be tried on several different kinds of animals, in order to decide if there is unity throughout the animal kingdom in regard to the path of the sensory nerves. Mïescher and Nawrocki have shown in the rabbit that they run exclusively in the lateral columns.

Method.—Cats were chloroformed, bound down, curarized, artificial respiration set up. Then the cord was bared high up, about the seventh dorsal vertebra, a section of it made with a protecting knife, and the wound closed. The carotid was prepared and also the sciatics. The arterial tension was noted before and after the section of the cord, and the sciatics irritated, and the rise noted. When both lateral columns were divided, then no irritation was able to elicit any rise in arterial tension. When, however, the whole cord was divided except a lateral column, then irritation of the sciatics sent the blood pressure up. If the gray matter was nearly wholly destroyed, then the rise of pressure occurred as well as before. These experiments left no doubt but that the vaso-motor fibres in the cat run in the lateral columns, as they do in the rabbit.

After a hemisection, irritation of the sciatic on the same side exhibited a rise of pressure nearly equal to that from irritation of the sciatic on the sound side. These experiments left no doubt but that sensory nerves decussate in the spinal cord. All these facts lead to the conclusion that:

1. The sensory fibres decussate in part in the spinal cord. This has been denied in the case of the cat.[1]
2. That the vaso-motor fibres also do.

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[1] Carpenter's Physiology, note, page 629, eighth edition.

3. That the sudorific here as elsewhere closely follow the vaso-motor and cross over.

4. That the vaso-motor fibres run in the lateral columns of the spinal cord.

Appended are experiments upon which the preceding statements are based.

Exp. 1.—Yellow cat, section of cord below 2d cervical vertebra, hemisection at the 6th dorsal vertebra, curarized: irritation of cervical cord caused paleness and sweating in both posterior extremities; complete section of the cord just below the hemisection prevented both. On the side of hemisection the paleness and sweating came on later than on the opposite side after an irritation.

Exp. 2.—Cat, curarized, hemisection of spinal cord at the 5th dorsal vertebra: irritation of the cervical cord caused paleness; prolonged irritation caused vaso-dilators to be set into activity.

Exp. 3.—Cat, curarized, hemisection at the 5th dorsal vertebra: irritation of the cervical cord caused sweating and paleness of the feet.

Exp. 4.—Cat, curarized, hemisection at the 7th dorsal vertebra: irritation of cut cervical cord caused paleness of the posterior extremities, but finally irritation caused congestion of the pulps.

Exp. 5.—Cat, curarized, hemisection at the 8th dorsal vertebra: irritation of the cut cervical cord caused paleness of both posterior extremities.

Exp. 6.	Distance between coils.	Time of irritation, in seconds.	Pulse before irritation.	Pulse after irritation.	Pressure before irritation.	Pressure after irritation.	Rise of pressure.	Time in which the pressure rose, in seconds.
Cat, curarized, all cut except the antero-lat. col. of one side, and that also considerably divided. Sciatic irritated before section ; knife inserted	0	5	3	3	174	300+	+120	7
Irritation of sciatic where lat. col. is intact, section at 7th dorsal vertebra . .	0	10	4	3.6	148	160	12	5
Irritation of sciatic on side of section	0	11	3.6	3	154	160	6	6
Exp. 7.								
Cat, curarized, knife in median line, sciatic irritated, hemisection of the cord at the 6th dorsal vert. Sciatic irritated before hemisection.	0	10	3	3.3	190	280+	+90	10
Sciatic on side of hemisection irritated	0	6.5	3	3.6	170	240	70	8
Sciatic of sound side irritated	0	9	3.1	3	140	200	60	15
Exp. 8.								
Cat, curarized, every thing cut except left lat. column at 12th dorsal. Sciatic irritated before section knife inserted	0	10	4.5	4	168	240+	72+	9
Right sciatic irritated . .	0	6	4	4	144	150	6	4
Left sciatic irritated . .	0	9	4	4.5	130	132	2	10
Exp. 9.								
Cat, curarized, two knives inserted, section at 6th dorsal vertebra of both antero-lat. columns. Sciatic irritated before section . .	4	11	3.5	3	164	230	66	5
Right sciatic irritated . .	4	10	4	3	158	158	0	0
Left sciatic irritated . .	4	15	3	3	115	115	0	0